Summary

In 1983, the U.S. Environmental Protection Agency (EPA) listed the Bunker Hill Mining and Metallurgical Complex in northern Idaho as a Superfund site on the National Priorities List (NPL). The basis for this listing was high levels of metals (including lead, arsenic, cadmium, and zinc) in the local environment and elevated blood lead levels in children in communities near the metal-refining and smelter complex. Initial cleanup efforts focused on the areas with the most contamination and the greatest risk of health effects—a 21-square-mile "box" in the heart of the Coeur d'Alene River basin. Children's blood lead levels in the box have declined remarkably since the 1970s when lead poisoning was epidemic. They now appear to be approaching those of same-age children in the U.S. general population.

In 1998, EPA began applying Superfund requirements[1] beyond the original Bunker Hill box boundaries to areas throughout the 1,500-square-mile Coeur d'Alene River basin project area. Soils, sediments, surface water, and groundwater are contaminated in areas throughout the basin with metals derived from historical mining operations, and a wide variety of studies have indicated that this contamination poses increased risks to humans and wildlife in the basin. In 2002, EPA issued a record of decision

[1]The Superfund requirements are set forth in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended (42 USC §§ 9601-9675 [2001]), and its implementing regulations are set forth in the National Contingency Plan (NCP) (40 CFR 300).

OVERVIEW OF CONCLUSIONS AND RECOMMENDATIONS

The committee found that scientific and technical practices used by EPA for decision making regarding human health risks at the Coeur d'Alene River basin Superfund site are generally sound. The exceptions are minor. However, for EPA's decision making regarding environmental protection, the committee has substantial concerns, particularly regarding the effectiveness and long-term protection of the selected remedy.

In the human health risk assessment (HHRA), EPA estimated potential lead intake by current and future populations of children using currently available risk assessment procedures with a reasonable degree of certainty. The application of the IEUBK model[a] was also reasonable but would have benefited from greater collection and use of additional site-specific information. Recognizing the importance of protecting current and future generations, remedial decisions regarding human health appropriately emphasized residential yard remediations. Given the prevalence of high concentrations of lead in soils of the studied communities and the potential for lead exposure of young children, the committee concludes universal blood lead screening of children age 1-4 years is warranted. This screening should be timed to coincide with other routine pediatric health care screening tests. Barring recontamination of remediated properties, it seems probable that the proposed remedies will reduce the targeted human health risks. However, long-term support of institutional-control[b] programs should be provided to maintain the integrity of remedies intended to protect human health and guard against health risks from recontamination.

For environmental protection, EPA's site characterization provided a useful depiction of the metal concentrations in soils, sediments, and surface water over the large spatial scale in the basin. However, the characterization did not adequately address groundwater—the primary source of dissolved metals in surface water—or identify specific locations and materials contributing metals to groundwater. In addition, the committee has serious concerns about the feasibility and potential effectiveness of the proposed remedial actions for environmental protection. There are no appropriate repositories to hold proposed amounts of excavated materials, and establishing them in the basin will probably be extremely difficult. Furthermore, the potential long-term effectiveness of proposed remedial actions is severely limited by frequent flooding events in the basin and their potential to

(ROD) that addressed the entire project area, excluding the box (which was the subject of earlier RODs). This ROD contained a "final remedy" to address contamination-related human health risks and an "interim remedy" to begin to address ecologic risks. These remedies are estimated to cost $359 million over 30 years—and even this effort will not complete the job.

Congress instructed EPA to arrange for an independent evaluation of the Coeur d'Alene Basin Superfund Site by the National Academy of Sciences (NAS). In response, the National Research Council (NRC) convened the Committee on Superfund Site Assessment and Remediation in

recontaminate remediated areas with contaminated sediments. Yet, flooding apparently received little attention in EPA's selection of remedies. Overall, downstream transport of lead-contaminated sediments can be addressed only by removing or stabilizing the contaminated sediments in the river basin. The committee recommends that the specific sources contributing zinc to groundwater (and subsequently to surface water) and the largest, potentially mobile sources of lead-contaminated sediments be ascertained, and priorities set for their cleanup. If zinc loading to groundwater is determined to stem from subsurface sources that are too deep or impractical to be removed, groundwater should be addressed directly. EPA should consider more thoroughly the potential for recontamination and proceed with those remedies that are most likely to be successful and durable. Because of the long-term and uncertain nature of the cleanup process, it is unrealistic to develop comprehensive remedial schemes and assess their effectiveness a priori. Hence, a phased approach to cleanup with defined goals, monitoring, and evaluation criteria (an adaptive management approach[c]) is warranted.

In general, the Superfund process has a number of serious difficulties in addressing the complex contamination problems in mining megasites such as the Coeur d'Alene River basin. Remediation involves long-term undertakings in which remedies will usually need to be developed over time, and efficient responses to the problems may require the implementation of programs outside the Superfund framework. EPA has demonstrated flexibility in applying Superfund to the Coeur d'Alene River basin and other megasites and has established a process in the basin that incorporates some of the characteristics the committee considers important to address the problems at such sites. However, it is unclear whether all the problems can be addressed efficiently and effectively within the constraints that govern the Superfund process.

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[a] The Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK model) was used at the Coeur d'Alene River basin site to select soil lead cleanup levels in residential yards.

[b] Institutional controls are actions, such as legal controls, that help minimize the potential for human exposure to contamination by ensuring appropriate land or resource use.

[c] Adaptive management is an approach where remediation occurs in stages and the consequences of each stage or phase are evaluated and provide feedback for planning of the next phase.

the Coeur d'Alene River Basin. The committee, composed of members with a wide range of backgrounds and expertise, was asked to consider EPA's scientific and technical practices in Superfund site definition, human and ecologic assessment, remedial planning, and decision making. During the study, the committee held public sessions in Washington, DC; Wallace, Idaho; and Spokane, Washington, where local, state, tribal, and federal officials, as well as private sector and citizen groups presented their views to the committee.

An important aspect of the study charge, beyond considering issues

specific to the Coeur d'Alene River basin, is to attempt to extrapolate "lessons learned" at this site to other large complex Superfund sites in the nation. In response, the committee developed recommendations to facilitate EPA's mission at other large, geographically complex mining megasites.

Remedial efforts within the Coeur d'Alene River basin will require much time, a great deal of money, and a concerted effort by involved parties. Thus, the question "Is it worth it?" is often raised. This question, however, depends on the requirements of the applicable federal laws and is not germane to the question of how the agency has implemented these laws. The committee has, as specified in its charge, focused on the agency's implementation and has not addressed the broader questions about the financial or societal value of these expenditures. Such questions go beyond matters that science alone can address. EPA undertook this difficult task at a time when knowledge of the disposition and effects of contaminants within the basin was evolving, and approaches to remediating large sites were poorly developed. Much has been learned since then, and it is through hindsight that this report reviews the process.

DECISION MAKING IN THE COEUR D'ALENE RIVER BASIN

EPA's scientific and technical procedures were generally appropriate and in accordance with the agency's standard procedures, as understood by the committee, for assessing risks to human health and the environment in the Coeur d'Alene River basin. EPA has also made substantial efforts to provide the public with information about its activities and to provide opportunities for public comment and input. However, the committee has concerns about several technical aspects of the analyses and has recommended various ways that EPA's standard techniques might be improved.

The committee recognizes that substantial controversy surrounds remediation at the Coeur d'Alene River basin site, and EPA's decisions were responsive, at least in part, to concerns of affected parties. For instance, cleanup efforts were strongly opposed both locally and within the Idaho state government, partially stimulated by fear of the economic consequences of having the entire basin declared a Superfund site. In contrast, other groups demanded site remediation and strongly opposed any approaches that would allow metals-contaminated media to remain in the environment following cleanup. Therefore, some decisions the committee considers suboptimal might have resulted from compromise with affected parties, as well as the reality of limited financial resources.

The discussion below is a synopsis of the committee's conclusions and recommendations provided throughout this report.

SITE CHARACTERIZATION AND REMEDIAL INVESTIGATIONS

In completing the remedial investigation (RI), EPA conducted, sponsored, and synthesized substantial research in cooperation with the state of Idaho, other federal agencies, and the Coeur d'Alene Tribe to evaluate the extent of metals contamination in the basin. Some of the research efforts are state of the art and should substantially inform the selection of appropriate remedies. Overall, EPA's evaluations provide a useful depiction of the location of contaminated soils, sediments, and surface waters over the large spatial scale of the basin. The data have been used to estimate average mass loading of metals in the Coeur d'Alene River and Lake and to provide an adequate description of contaminants moving through much of the system.

Nevertheless, the committee has identified some serious weaknesses in the RI. EPA has not adequately characterized the substantial hydrologic and climatic variations that can occur in the basin. Contaminant transport models are based on average flows and conditions, and the RI only minimally characterizes the extreme events (for example, flood events that transport large amounts of contaminated sediments) that substantially affect the fate and transport of metals throughout the basin. In addition, EPA's segmentation of geographic areas within the basin for assessment and remedial actions does not facilitate a basinwide analysis of sources, transport, and fate of contaminants. In particular, remediation of the Bunker Hill box is under a separate administrative structure, yet this area contributes substantially to downstream contamination.

To support remedial decision making adequately, the specific source areas[2] of contamination releasing dissolved and particulate metals should be characterized. Instead, EPA inferred source areas contributions of metals largely from surface-water studies and not, for example, from studies of metal leachability from source materials. EPA's site characterization also did not adequately address groundwater—the primary source of dissolved metals in surface water. Understanding the contamination of groundwater by aquifer materials, the dynamics of groundwater movement, and the complex relationship between surface water and groundwater will require additional study.

Evaluations of chemical speciation and mineralogy were extremely limited in the RI. As metals move though the system, their chemical form can change and affect, for example, their ability to be absorbed by organisms if ingested (bioavailability) or their ability to leach into groundwater from

[2]Source areas are the specific locations of materials that contribute contaminants to environmental media of interest (for example, surface water or groundwater).

aquifer material. For Lake Coeur d'Alene, additional characterization of the behavior of metals in lake sediments and the relationship between eutrophication and metals release is also needed.

Recommendations

In its remedial planning, EPA should incorporate new data that have been made available by the U.S. Geologic Survey (USGS), the Coeur d'Alene tribe, and others since issuance of the ROD and should proceed, as planned, with more thorough source identification before cleanup to verify the location, magnitude, disposition, and contributions from contaminant sources.

A better understanding of dissolved metals, particularly zinc, is needed to account for movement to and from groundwater and surface water. The chemical and hydrologic components of the assessment should be sufficiently rigorous to identify source areas of contaminants and permit evaluation of the consequences of alternative remedies to the transport of dissolved metals through the system.

Understanding the speciation of metals is important to characterize risk more effectively and ascertain the potential effectiveness of remedial actions. Speciation information should be collected and examined to elucidate the potential for metal transport and the effect of transformation processes on the fluxes and bioavailability of metals.

HUMAN HEALTH RISKS AND REMEDIAL DECISIONS

Human Health Risk Assessment (HHRA)

The HHRA sought to estimate risks to human health associated with estimated concentrations of environmental contaminants, particularly lead and arsenic, and to calculate cleanup concentrations that would protect human health.

EPA estimated potential lead intake by current and future populations of children according to current risk assessment procedures with a reasonable degree of certainty. Consequently, the committee concluded that EPA's HHRA is correct in concluding that environmental lead exposure poses elevated risk to the health of some Coeur d'Alene River basin residents. The committee agreed that subsistence activities, if they were to be practiced, would be associated with elevated risk. EPA also applied reasonable methods to apportion risk among exposure sources, including those unrelated to mine wastes. EPA concluded that although lead from old house paint probably contributed to the exposure of some children, lead-contaminated soil was the primary contributor to health risk from lead.

Children of ages 1 to 4 are the group at highest risk from lead exposure. The committee found it inappropriate that the HHRA presented aggregate data on childhood lead screening for children 0-9 years old, as that information is misleading and tends to underestimate the risk among the principal target group. Furthermore, the annual blood lead sampling of children at fixed sites is suboptimal and produces results with too much potential for nonrepresentative sampling to evaluate the effectiveness of public health intervention strategies in the basin. Universal blood lead screening of children 1-4 years old is warranted for Coeur d'Alene River basin communities, given the prevalence of high concentrations of environmental lead.

For arsenic, EPA collected no information about actual human uptake and based its risk assessment on arsenic concentrations in environmental samples. Biological indicators of actual human arsenic exposure would serve to strengthen future risk assessments at sites such as Coeur d'Alene, though the committee recognizes the limitations of the currently available arsenic biomarkers.

The effects of psychological stress on mental health are not considered in the HHRA. However, there is strong scientific evidence that living in or near an area designated as a Superfund site is associated with increased psychological stress and may also cause adverse health effects.

Recommendations

Health surveillance activities conducted or sponsored by local, state, or federal (for example, the Agency for Toxic Substances and Disease Registry [ATSDR] or EPA) entities should include the following:

- Annual blood lead screening of all children 1-4 years old who live in the basin. Screening should be coordinated with local health care providers and timed to coincide with other routine health care screening tests. These data would be useful for evaluating the efficacy of the remedial activities.
- Health interventions that address possible consequences of chronic psychological stress. These may have significant community benefits and should be implemented before or concurrent with cleanup efforts.
- Continued research at the national level on biomarkers of human arsenic exposure to strengthen future HHRAs.

Use of the Integrated Exposure Uptake Biokinetic (IEUBK) Model

A major controversy at the Coeur d'Alene River basin site arose because EPA did not base its risk assessment and remediation decisions on the blood lead levels that had been measured but on the IEUBK model to estimate potential levels and related health risks.

EPA's remediation goal for lead in soil states that a typical child or group of similarly exposed children should not have more than a 5% estimated risk of exceeding a blood lead level of 10 micrograms per deciliter (μg/dL). Because protecting the future, as well as current, residents is important and because measuring attainment of the remediation goal is not possible, the use of a model that predicts such risks is necessary and appropriate. Multicompartment predictive blood lead models, such as the IEUBK model, are powerful tools for assessing pediatric risk from lead exposure, exploring lead risk management options, and crafting remediation strategies.

At the Coeur d'Alene River basin site, EPA's application of the IEUBK model was generally adequate and appropriate, but not optimal. Additional collection and use of site-specific information, particularly site-specific bioavailability and ingestion rates, would have improved the application of the model. The credibility of the results would have been enhanced by greater use of alternative tools (for example, other models and epidemiological studies) to assess the reliability of IEUBK model predictions and better characterization of the physical-chemical properties of the exposure source materials.

The committee also provides several conclusions regarding the model and recommendations for the model's future development and application. The committee concluded that, in general, the design and functioning of the IEUBK model are consistent with current scientific knowledge; however, the committee concluded that there were some technical issues, particularly the uncertainties associated with the default assumptions for bioavailability of soil lead, soil and dust ingestion rates, and the parameter used to extrapolate from a single blood lead estimate to the distribution of concentrations throughout a population.

EPA regulatory guidance on the use of the IEUBK model in conjunction with data from blood lead surveys is incomplete, particularly on actions to take when blood lead studies and IEUBK model results disagree by a substantial margin. The guidance states that model results are to take precedence in those cases; however, a more comprehensive articulation is required. The committee concluded that the model's inherent uncertainties coupled with the need to protect present and future populations necessitate additional information (such as blood lead studies) to help characterize the model's uncertainties. This is particularly true at large mining megasites, such as the Coeur d'Alene River basin, where physical site characteristics and human exposure profiles can vary widely across the large geographic area. At those sites, the IEUBK model results should not be the sole criterion for establishing health-protective soil concentrations because model uncertainty and site complexity may interact in unexpected or unknown ways.

Recommendations

EPA should pursue initiatives to improve the knowledge base for soil and dust ingestion rates and consider whether soil ingestion rates are site specific. EPA should also pursue implementation of a model version that provides a probabilistic distribution of blood lead concentrations in a population.

EPA should require that cleanup levels derived from the IEUBK model be supported by site-specific measures of bioavailability and concentrations of lead in various sizes of soil particles.

EPA should clarify guidance on using the IEUBK model in conjunction with blood lead studies, particularly when reconciling differences between modeled and observed blood lead levels and when considering the uncertainties associated with each.

A comprehensive revision of the 1998 EPA directive on IEUBK model use at large geographically complex sites is needed. The revision should establish a decision-making structure for determining site cleanup concentrations and specifications based on the IEUBK model's predictive capability, blood lead study results, economic feasibility, and long-term remedy protection.

Remedial Decisions Regarding Human Health

The committee concluded that EPA adequately characterized the feasibility of alternative remedial actions for addressing risks to human health; however, the long-term effectiveness of the selected remedy in the Coeur d'Alene River basin is questionable because of the possibility, even likelihood, of recontamination from floods and damage to protective barriers used in residential remediations.

Barring recontamination, it seems probable that the proposed remedies will reduce the human health risks addressed. There are logical reasons to expect that residential yard remediations decrease lead exposure, and available evidence suggests the efficacy of this approach within the Bunker Hill box. Thus, the strategy for yard remediation is supportable even though the scientific evidence supporting substantial beneficial effects is currently weak.

Recommendations

Long-term support of institutional-control programs should be provided to avoid undue human health risks from recontamination and to maintain the integrity of remedies intended to protect human health.

The effectiveness of remedial actions for human health protection needs to be further evaluated. This evaluation should be supported by ongoing environmental and blood lead monitoring efforts.

ENVIRONMENTAL RISKS AND REMEDIAL DECISIONS

Ecologic Risk Assessment (ERA)

EPA's ERA describes the likelihood, nature, and severity of adverse effects on plants and animals resulting from exposure to metals associated with mining operations throughout the study area. The committee found the assessment to be generally consistent with best scientific practices. In some respects, it was substantially more extensive than ERAs at many other sites. However, support for conclusions on different organisms and habitats is highly variable. Conclusions about waterfowl are especially strong because of the wealth of data on dose-response relationships developed by USGS and the U.S. Fish and Wildlife Service, but conclusions on other organisms, particularly in riparian and upland communities, are much less certain. Deficiencies that precluded a thorough assessment of impacts on some biota and on large portions of the basin are also apparent. For example, few measures of community structure and site-specific toxicity tests were used to characterize risks to fish and benthic macroinvertebrates in the lower Coeur d'Alene River. The Lake Coeur d'Alene assessment was not supported by studies to evaluate whether metal concentrations in sediments or overlying waters were impacting ecologic communities. Finally, in considering effects on organisms, the high variability in exposures related to extreme events, including low-flow conditions and flood events, was not considered.

Overall, the committee was surprised at the minimal extent to which EPA used the ERA in subsequent decision making. Preliminary remediation goals (PRGs) (concentrations of metals intended to protect organisms) developed for fish, benthic invertebrates, small mammals, plants, amphibians, and birds other than waterfowl are based on national regulatory criteria, literature-derived values, or background concentrations. PRGs derived in that fashion are highly uncertain and have questionable value for guiding remediation decisions. Of the PRGs, only the national ambient water quality criteria were adopted from the ERA as remediation goals in the ROD.

Recommendations

Further evaluations of the impacts of exposures to metals in the aquatic and terrestrial environment are needed to support remedial actions intended to promote recovery of biota within the basin.

In developing restoration goals and performance metrics, additional consideration should be given to habitat modifications (for example, stream channelization) resulting from human activities that may prevent a return to premining conditions.

Remedial Decisions for Protecting the Environment

EPA used the feasibility study to select, document, estimate the cost of, and compare five alternative strategies for environmental protection. Despite the extensive effort and documentation, none of these alternatives was selected. The remedial strategies in EPA's ROD for protecting the environment are presented as "interim remedies," and the committee is encouraged that EPA took this approach. At a site of this size and complexity, developing comprehensive remedial schemes and assessing their effectiveness a priori is not realistic. The on-the-ground effect of remedial actions is often unknown, as are unforeseen conditions that make solutions that appear feasible on paper, infeasible in the field. EPA is proposing to use adaptive management to implement interim ecologic protection remedies; however, the committee is concerned about the rigor of EPA's adaptive management approach at this site, particularly regarding performance indicators needed to evaluate progress.

The feasibility and effectiveness of EPA's proposed remedial actions to protect fish and wildlife resources have not been adequately characterized. These actions can be roughly described as those intended to stem the influx of dissolved zinc to surface waters and as those intended to reduce the transport of lead-contaminated sediments through the basin and the effect of those sediments on waterfowl. Removal of contaminated materials is a core constituent of both strategies, yet the lack of available repositories (or even identified locations) is particularly problematic. Still, the committee recognizes that contamination problems in the study area will be solved only when the contaminated materials in the river basin have been removed or stabilized.

The threat to aquatic life in the basin results primarily from the influx of high levels of dissolved zinc from groundwater to surface waters. Yet, groundwater has not been targeted for remediation. Removing contaminated materials as a means to curtail fluxes of metals to groundwater and subsequently to surface water is a logical strategy. However, the specific source areas contributing zinc to groundwater throughout the basin are not well understood, so it is not clear if proposed removals will have an effect on surface-water concentrations. Evidence of the effectiveness of prior removals of materials in the basin has not demonstrated a substantive effect in reducing surface-water concentrations of zinc. A major portion of the dissolved zinc in the lower basin results from groundwater seepage through the Bunker Hill box, a source that is not addressed in the ROD for the basin.

The Coeur d'Alene River basin is a system where floods have a fundamental role in the resuspension and distribution of contaminants and particularly in the potential recontamination of remediated areas, includ-

ing wetlands and river banks, by contaminated sediments. An understanding of the source areas of these contaminated sediments is evolving. Although impacts to waterfowl in the lower basin are severe, the durability of proposed remedial efforts to protect waterfowl is highly questionable. In addition, recontamination of wetlands by flood waters containing lead-contaminated sediments would quickly undo the benefits of remediation. The committee sees the need for such measures as restoring wetlands on agricultural lands in the lower basin and upgrading the quality of the habitat in existing wetland areas that have the least likelihood of being recontaminated.

Recommendations

EPA should improve its planned adaptive management approach by establishing unambiguous links between management objectives, management options, performance benchmarks, and quantitative monitoring indicators for the habitats and ecologic communities addressed in the ROD.

Remedial Efforts to Address Zinc in Surface Water

As part of its remediation planning, EPA should seek to locate those specific sources contributing zinc to groundwater (which is subsequently discharged to surface water) and set priorities for their remediation. If it is determined that loading to the groundwater stems from subsurface materials too deep or impractical to be removed, groundwater should be addressed directly.

EPA should continue to support research on and demonstration of lower-cost innovative groundwater treatment systems. In particular, EPA should place a high priority on identifying possible methods of reducing metal loading in groundwater from the Bunker Hill box and highly-affected basin tributaries.

Remedial Measures to Address Transport and Effects of Particulate Lead

Recontamination of remediated areas from flooding is a major concern. In selecting sites for remediation, EPA should consider the potential for recontamination and proceed with remedies that are most likely to be successful and durable. To the extent that water yield and flooding can be managed through land-use practices, it is important to include these practices in schemes designed to protect human and ecosystem health.

Remedial measures should address the largest potentially mobile sources of lead-contaminated sediments and seek to address those sources with the

highest potential for contributing such sediments to the system. To facilitate such measures, EPA should develop a quantitative model for sediment dynamics, deposition, and geochemistry for the basin watershed. In designing and implementing remedies, consideration should be given to possible unintended effects, such as impacts to fluvial behavior and migration of resuspended sediments.

MINING-RELATED MEGASITES

Superfund megasites are often defined as those sites with projected cleanup costs expected to exceed $50 million. In this section, the committee restricts its conclusions to mining-related megasites that, in addition to their high costs for remediation, include massive amounts of wastes resulting from many years of mining activities. Wastes at these sites are dispersed over a large area and deposited in complex hydrogeochemical and ecologic systems that often include human communities and public natural resources.

The committee concludes that an effective program for mining megasites should emphasize long-term adaptive management. The desirable program components are a stable management structure, long-term monitoring components, active state and local involvement in the remediation process, a broad perspective regarding what actions should be undertaken in addition to cleanup, and long-term funding.

Most of the committee's recommendations regarding mining megasites can be implemented within the Superfund framework; some reflect actions that EPA has already undertaken to some extent in the Coeur d'Alene River basin; and some probably cannot be implemented under the current framework, at least not without private or nonprofit partnerships.

Recommendations

Design the data collection, evaluation, and decision-making process at mining megasites so that the remediation program focuses on establishing a durable process for long-term management of the sites, as final remedies may not be realistic at some megasites.

Be ready to waive specific "applicable or relevant and appropriate requirements" (ARARs) if an effective monitoring program demonstrates that those numeric standards are not necessary to achieve the basic goals of protecting human health and the environment.

Where final remedies cannot be realistically implemented, establish a rigorous and responsive adaptive management process for environmental remediation. ERAs at such sites should be designed to support remedy selection, and move beyond documentation of the presence or absence of

risks. In particular, the ERA should be a source of performance metrics and restoration goals for use in an adaptive management strategy.

Establish an independent external scientific review panel with multidisciplinary expertise to provide ongoing evaluations and advice to the relevant agencies on remediation decisions at mining megasites. Although this recommendation may appear to add to the bureaucratic process, at particularly complex sites it may well speed cleanup, avoid excess costs, and provide a mechanism for resolving technical disagreements.

Broaden the goals of the cleanup to include restoration of habitat for ecologic resources to the extent required to meet biological performance goals. For affected communities, provide economic assistance and comprehensive medical support services that acknowledge the broad effects that toxic waste sites have on health.

Encourage development of alternative and innovative technologies, including responsible re-mining as remedial strategies. Consider offering indemnification to private or nonprofit entities that participate in cleanup, agreeing that their liability will be limited to problems resulting from the remediation activity.[3]

Look for opportunities to provide long-term support for implementing and maintaining the cleanup activities and stewardship of the land. Possible sources of such support might include special appropriations by Congress, trust funds, or partnerships with private organizations.

Both risk assessment and risk management activities should be structured according to the natural environmental system boundaries; they should not represent the aggregation of policies previously used at smaller, simpler locations.

[3]Such relief should not be afforded to any responsible party at the site who has not entered into a binding settlement agreement with EPA regarding its cleanup liability.